CBRS HAS LAUNCHED!

Wireless Innovation Forum Webinar
January 28th, 2020

Administrivia

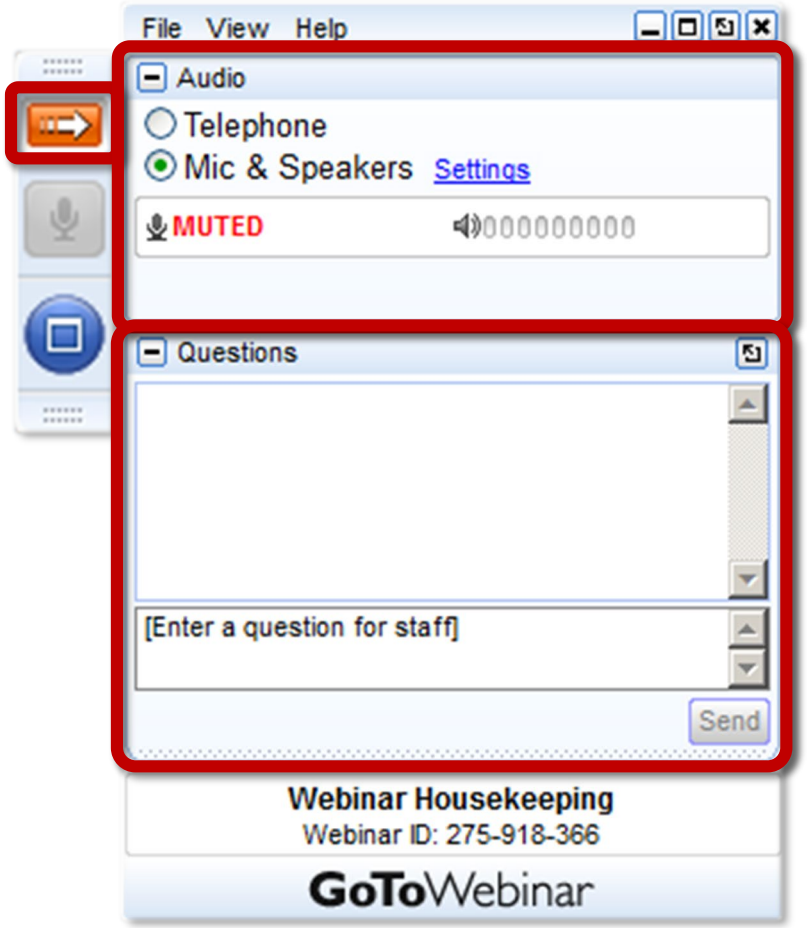
Slides presented during this webinar are available in the handouts and will be posted here:

- http://www.wirelessinnovation.org/webinars

Recorded Webinar will be available on the Forum's You Tube Channel:

- https://www.youtube.com/channel/UCYUeZvOuJTP27OzoKsyys0w

Email Lee.Pucker@wirelessinnovation.org if you need more information



Today's Agenda

Functional Overview of CBRS

- Presented by Andrew Clegg, Google and Chair of the WInnForum Spectrum Sharing Committee CBRS Functional and Operational Requirements Work Group

Deployment of CBRS and Use Cases

- Presented by Richard Bernhardt, National Spectrum Adviser at WISPA and Chair of the WInnForum Spectrum Sharing Committee CBRS Operations Work Group

CBRS Standards Update

- Presented by Lee Pucker, CEO of WInnForum

What Is the “Wireless Innovation Forum”

The Wireless Innovation Forum is a nonprofit “mutual benefit corporation” dedicated to:

“advancing technologies supporting the innovative utilization of spectrum and the development of wireless communications systems, including essential or critical communications systems”

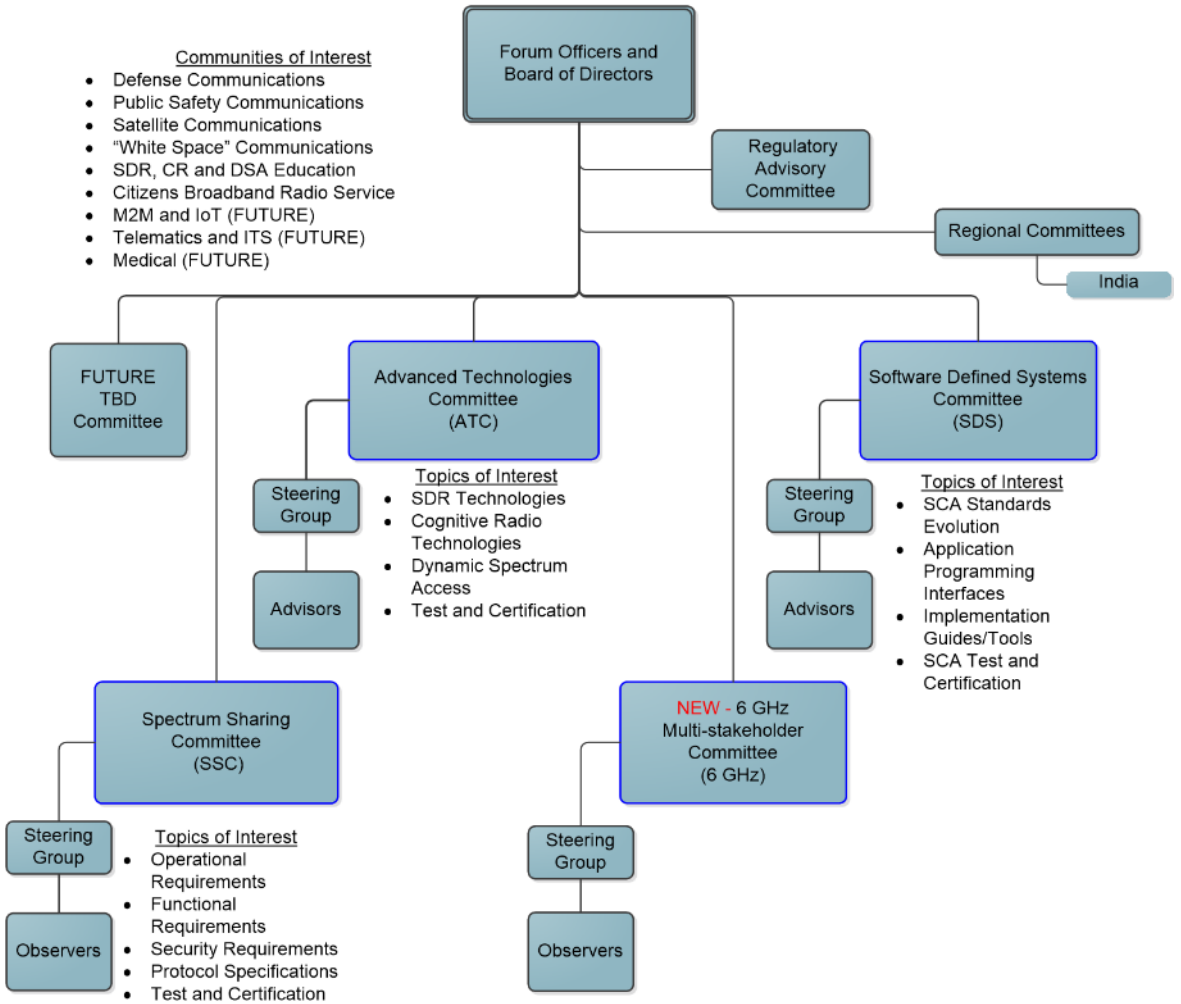
CBRS WInnForum Standards

WIRELESS INNOVATION FORUM

WInnForum Structure

Organizational Structure for The Wireless Innovation Forum

23 August 2019



CBRS Standards Development Within the Forum: 376 Participants, 60+ Organizations

And many more…

A Functional Overview of CBRS

Andrew Clegg
Google
Chair, WInnForum Spectrum Sharing Committee
CBRS Functional and Operational Requirements Work Group

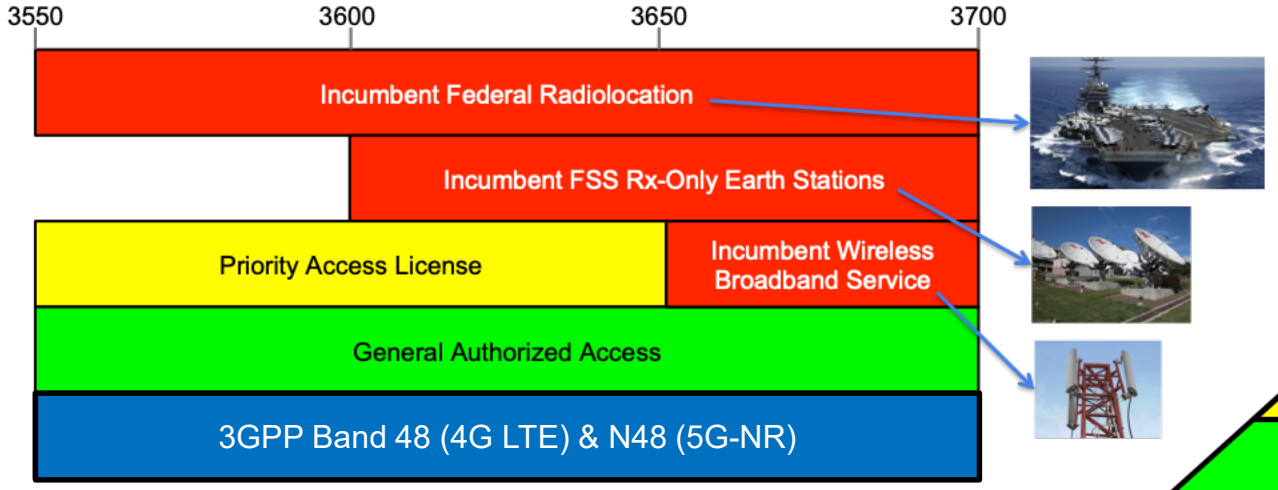
CBRS *has* launched!

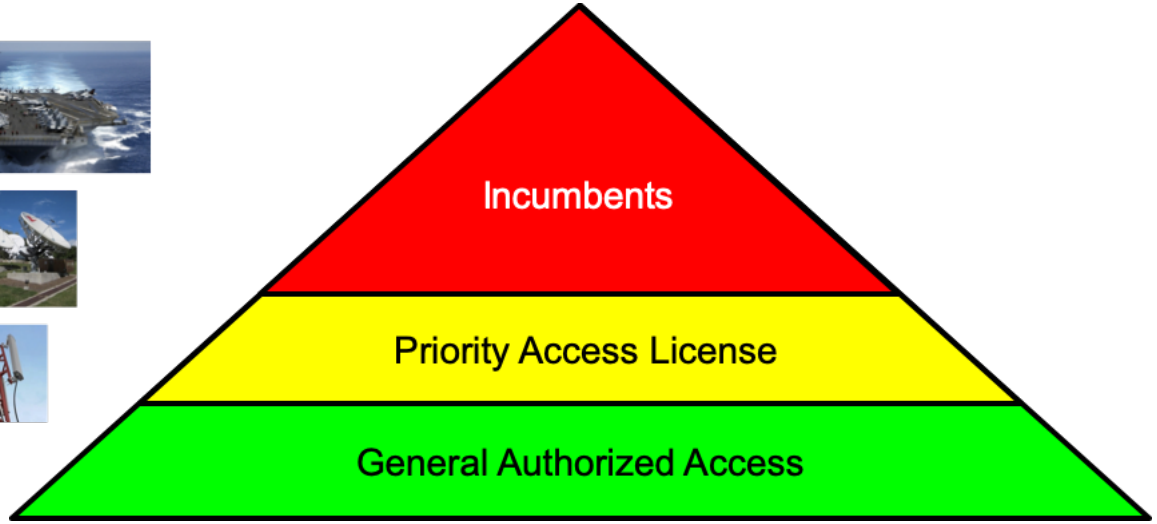
- **FCC released a Public Notice yesterday authorizing full commercial service by four Spectrum Access Systems**
  - Another expected shortly
  - Additional applicants are in a queue for ”wave-2” approval
- **Initial Commercial Deployment (ICD) (CBRS on training wheels) is over, and unrestricted deployments of SAS-managed devices is now allowed**

CBRS Spectrum & Three-Tier Sharing Structure

- **CBRS is a three-tier spectrum sharing framework:**
  - Tier 1: Incumbents
  - Tier 2: CBRS Priority Access License (PAL)
  - Tier 3: CBRS General Authorized Access (GAA)

- **A cloud-based Spectrum Access System (SAS) manages interference from the CBRS tiers into the incumbents, interference within the PAL tier, and interference from GAA into PAL**



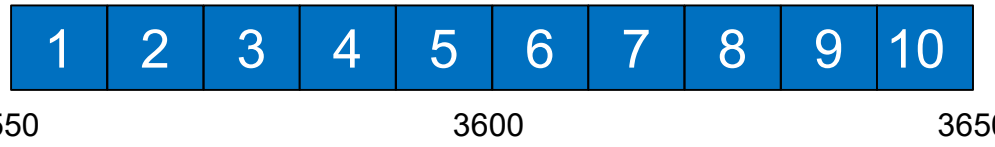


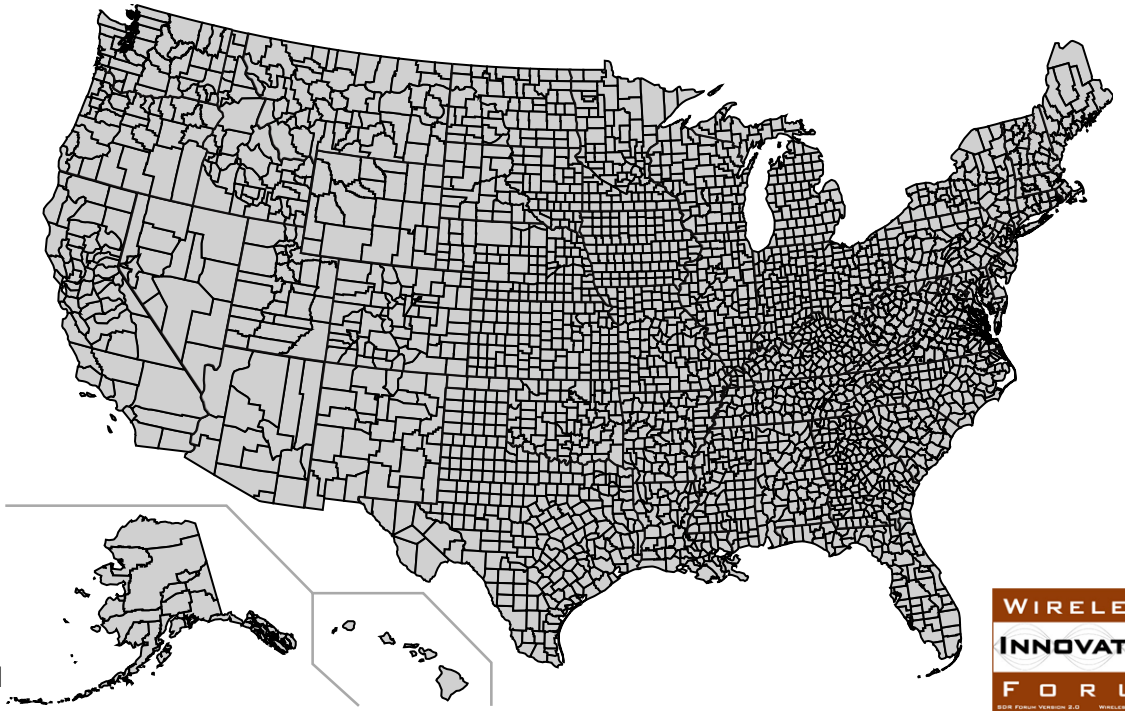
Tier 1: Incumbents

- **Incumbents**
  - Federal government
    - Mainly shipborne radar operated in coastal areas
    - Some inland radar sites
    - Protected from aggregate interference due to CBRS
    - Radar activity is generally detected by Environmental Sensing Capability (ESC) networks; some are informed to SASs by the government through a portal
  - Fixed-satellite service (FSS) receive-only earth stations
    - Approximately 20 extended C-band sites, mostly on east and west coasts
    - Most operate down to 3625 MHz, some down to 3610 MHz
    - Protected from aggregate interference and blocking interference due to CBRS
  - Grandfathered Wireless Protection Zones (GWPZ)
    - Legacy Part 90 operations in 3650-3700 MHz
    - Most GWPZs expire starting in March 2020
    - A few will remain as late as January 2023
    - Protected from aggregate interference caused by CBRS, until expiration
    - Many grandfathered operators are transitioning to CBRS

Tier 2: CBRS Priority Access License (PAL)

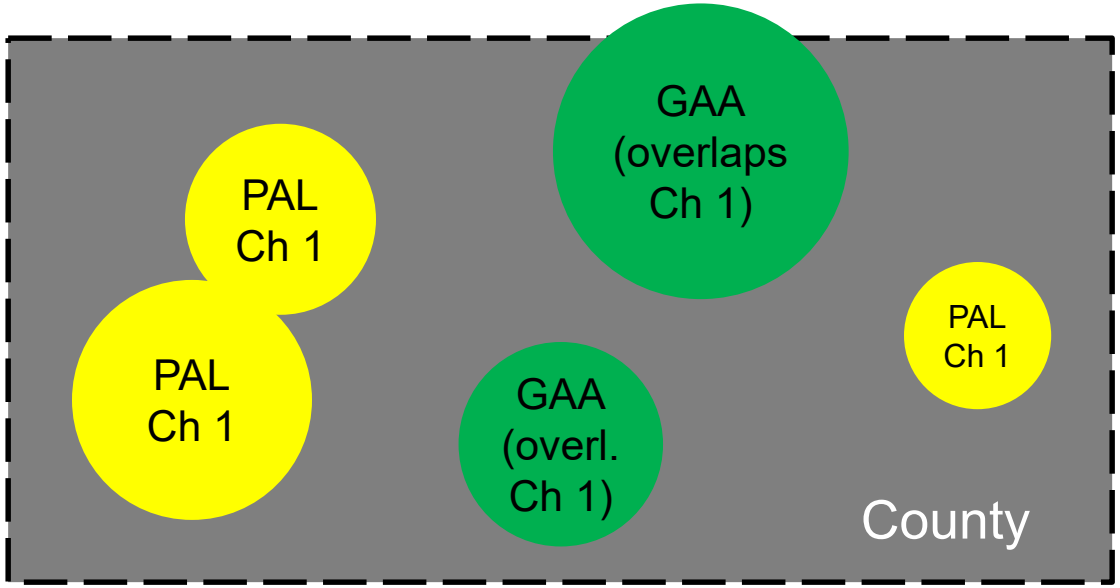
- **Priority Access License (PAL)**
  - License bought at auction that provides defined interference protections from other PALs and all GAA
  - One PAL = one 10 MHz channel in one license area (county)
  - PAL channels are in the 3550-3650 MHz segment. No PAL channels in 3650-3700 MHz.
  - Up to seven PAL channels will be auctioned in one county (70 MHz max total PAL)
  - An individual PAL licensee may own up to four PAL channels in a county (40 MHz max per licensee)
  - License term is 10 years, with expectation of renewal subject to buildout requirements
  - PAL spectrum is use it or share it
    - GAA can use a PAL's spectrum in portions of the county where the PAL is not using it
  - FCC's PAL auction scheduled to begin June 25th
    - Auction #105
    - Proposed minimum bid for a PAL set to $0.20 per pop, but not less than $1,000
  - PALs can be leased/disaggregated/partitioned





Tier 3: CBRS General Authorized Access (GAA)

- **General Authorized Access (GAA)**
  - "Lightly-licensed"
  - No pre-defined bandwidth or term
  - No cost for spectrum
  - Can operate anywhere in 3550-3700 MHz, subject to incumbents and PALs
  - 3650-3700 MHz is GAA only (no PALs)
  - GAAs can use PAL licensed spectrum in portions of license area where PALs are not in use



GAA can operate co-channel with PALs in portions of a license area (county) where PAL is not deployed.

The Spectrum Access System

- **Spectrum Access System (SAS)**
  - SAS is the glue that holds CBRS together
  - SASs (there is more than one) are cloud-based systems whose purpose is to manage interference from CBRS devices into incumbents, and among CBRS devices (PAL/PAL and GAA/PAL)
  - No CBRS device may transmit without prior authorization from a SAS
  - Four SAS Administrators were approved yesterday for full commercial service (CommScope, Federated Wireless, Google, Sony)
    - A fifth should follow shortly
    - Five more are in the pipeline
  - A CBRS user may choose their SAS provider

CBRS Equipment Nomenclature

- **Citizens Broadband Radio Service Device (CBSD)**
  - i.e., the base station
- **CBSDs can be operated as either Category A or Category B**
  - Next slide for more details
  - Don't confuse Category A and Category B with PAL and GAA. Either can be either!
- **CPE CBSD**
  - Special category of CBSD that can bootstrap its connection to a SAS through another CBSD
  - Used in instances where there is no back channel to a SAS

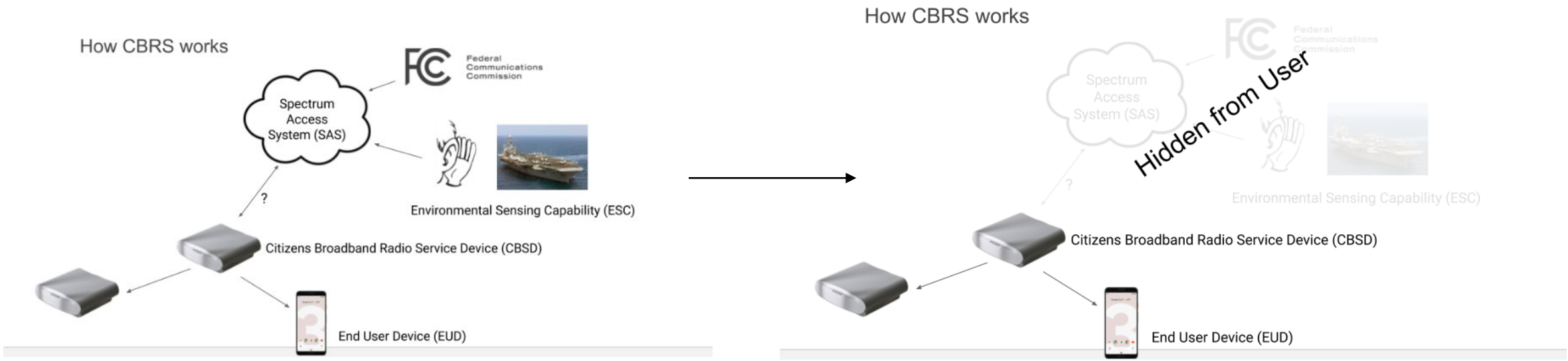
- **End User Device (EUD)**
  - i.e., the handset, dongle, IoT device, or other user device

Citizens Broadband Radio Service Device (CBSD) Categories

Device	Max EIRP per 10 MHz	Indoor Operation	Outdoor Operation	Professional Installation Required?
Category A CBSD	1 W	Allowed	Allowed at or below 6 m HAAT, otherwise must be operated as Category B	If unable to geolocate to required accuracy (50 m horizontal x 3 m vertical)
Category B CBSD	50 W	Not allowed	Yes. No height limit.	Always
End User Device (EUD)	200 mW	Must be under control of a CBSD. SAS does not manage EUDs nor does it have any knowledge about EUDs.		

Spectrum Access System Functionality

- **All of the functionality of the Spectrum Access System is transparent to a CBRS user**
- **A CBSD automatically registers with a SAS, or a professional installer registers the CBSD directly with a SAS, and all interference management occurs in automated exchanges between the CBSD and the SAS**

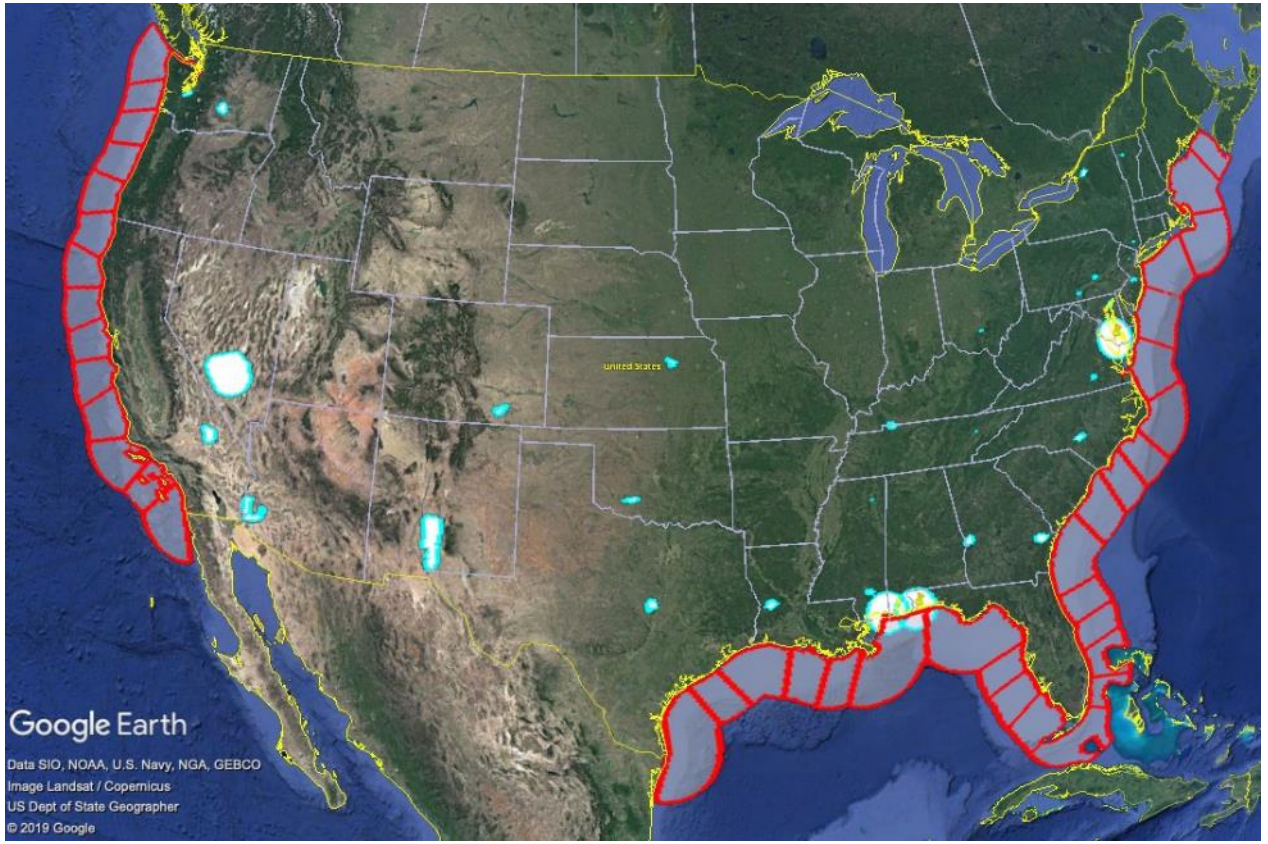


Equipment Ecosystem

- **CBSDs**
  - The FCC has certified a few dozen CBSDs, which are now available for commercial service
  - A complete list of certified CBSDs can be found on the FCC's Equipment Authorization System search page
    - Choose "CBD-Citizens Band Category A and B Devices" in the equipment class to get a list of certified CBSDs
- **EUDs**
  - Several dozen end user devices and modules have been certified by the FCC
  - A complete list of certified CBSDs can be found on the FCC's Equipment Authorization System search page
    - Choose "CBE-Citizens Band End User Devices" in the equipment class to get a list of certified EUDs and modules

Incumbent Protections

- **If you plan to participate in the PAL auction, be sure to familiarize yourself with incumbent protections.**
- **The protections are a complex combination of geography, frequency, and time**
- **Consult your preferred SAS Administrator for more information**



More Information & Resources

- **FCC's CBRS Rules**
- **WInnForum CBRS Standards**
  - Release 1 Functional and Operational Requirements
  - Release 2 Functional and Operational Requirements (brand new!)
  - All WInnForum Release 1 CBRS standards
  - All WInnForum Release 2 CBRS standards
- **Incumbent Data**
  - NTIA GIS files describing federal incumbencies
  - FCC Information on FSS incumbents
- **CBRS Alliance**
  - Advocates for 3GPP-based (4G LTE and 5G NR) deployments in CBRS, under the OnGo™ brand
  - List of OnGo-certified devices
- **FCC's Equipment Authorization System search page**
  - Where you can view a (not particularly user-friendly) list of FCC-certified CBRS equipment
  - In the Equipment Class dropdown, choose CBD for CBSDs, or CBE for end user devices

Deployment of CBRS and Use Cases

Richard Bernhardt
National Spectrum Adviser, WISPA, http://www.wispa.org
WInnForum Spectrum Sharing Committee
CBRS Operations Work Group Chair

Essential Steps to Enter the Band

Learn the basics of the rules and standards/specifications of the CBRS shared spectrum use band (3550-3700 MHz).

Plan your network to establish your needs. Understand your geography and any limitations of the band.

Establish relationships with the supply chain for CBRS equipment and service needs.

Establish a relationship with one or more Spectrum Access System Administrators (SAS). This may be directly with a SAS or through a relationship with a manufacturer or otherwise.

Establish a relationship with Certified Professional Installer(s) (CPIs).

Determine how you are going to use CBRS spectrum. Primary? Secondary? 5G, Fixed Wireless, other. Determine whether you will use only GAA or later seek PAL access.

Transitioning from FCC Part 90 Subpart Z 3.65 GHz NN License to CBRS in Part 96

Check the date of your Part 90 license against the language in Part 90. <u>Many licenses will sunset (expire) as of April 17, 2020.</u>

Verify with your equipment provider whether the equipment you have deployed (CBSD) is software and/or firmware upgradable to meet Part 96 requirements.

Viable CBRS Ecosystem Equipment: All equipment must meet the requirements of Part 96 including the capability to talk/communicate with the SAS (or via Domain Proxy); cover 150 MHz of the band spectrum (with a few exceptions), have frequency and power control by the SAS, and meet spectral, power and out of band limitations.

If you have a current Part 90 Subpart Z 3.65 GHz NN license, and it remain current, and, you are registered for Grandfathered Wireless protection in CBRS, you may not be able to operate in CBRS in the same geography and frequencies.

When can you transition? For commercial purposes, the earliest is ICD if registered, or General GAA commercialization.

Who Will Want to Use CBRS? – Use Cases Examples

Fixed Wireless Networks (Indoor and Outdoors)
WISP (Wireless Internet Service Providers)
Indoor Networks (e.g. Private LAN)
Extensions of Cable Networks/Operators (MSOs)
Utilities and energy

Internet of Things (IoT) and Industrial Internet of Things (IIoT)
Security and surveillance
Industrial, commercial and residential monitoring
Agricultural (such as moisture sensors) and dairy sensors
Parking and building functions

Private Networks (Single or many locations/geographies)
Industrial or Business
Multiple Unit Dwellings (MDUs) or Multi-Tenant Enterprises (MTEs)

Neutral Host Networks (Networks which can accommodate more than one host)
Venues, Stadiums, Accommodations
Workplace

Mobile Networks and 5G LTE and NR
Mobile Network Operations (MNOs)
Private mobile networks

Example Vertical Markets for CBRS

- **Medical/Dental Office and Hospitals and Centers**
- **Education (K-12 and Higher Ed)**
- **Industry and Commercial**
- **Security and Surveillance**
- **Hospitality and Accommodations**
- **Venues, Stadiums, Public Places**
- **Multi-Family Residential**
- **Multi-Tenant Enterprise**
- **Airports and Campuses**
- **Oil and Gas**
- **Energy**
- **Power and Utilities**
- **Telecommunications**
- **Entertainment …. And More.**

Installing CBSDs Cat A and B Using CPI – When Do I Need A CPI?

"CPIs are responsible for assuring that the registration data entered into the Spectrum Access System (SAS) for certain types of CBRS devices is accurate and the device valid to be registered and request a spectrum grant to operate." - WInnForum

All Category B CBSDs (+30 dBm-47 dBm/10MHz EIRP) All Category B CBSDs require CPI. Examples include base stations, CPE (Client Premises Equipment), eNodeB (eNb), AP, subscriber units, and etc.

Most Category A CBSDs (+23 dBm-30 dBm/10 MHz EIRP) require CPI Examples are: Indoor CBSDs, low power outdoor fixed devices, etc.; Indoor devices above 6M height above average terrain (HAAT) require a CPI. If unable to self geo-locate, must use CPI.

CPE-CBSD: A "CBSD" device which may need to connect, register and gain its grant via CBRS spectrum (generally via an access point/eNodeB/base station with an already approved grant. It is required by professionally installed because it is a CBSD.

End-User Devices – EUDs (up to +23 dBm/10 MHz EIRP) *Does not require CPI*. Examples are mobile phones, low power non-serving devices.

Becoming a CPI – Training Programs

Current List of Approved Training Program Administrators for CPI Training through WInnForum:

- **CommScope**
- **Federated Wireless, LLC**
- **Google, LLC**
- **Nokia Corp.**
- **C3Spectra**
- **Others**: As Announced by WInnForum (*see*):
- https://cbrs.wirelessinnovation.org/cpi-program-administrator

Using GAA (Licensed by Rule) – Can Anyone Use It? Yes with Conditions

Per FCC Part 96 GAA Spectrum: General Authorized Access (GAA) Users may operate in the 3550-3700 MHz frequency band.

Open and Unused Spectrum: Any unused (and not requiring protection) CBRS frequency may be considered GAA. The statement, "Use it or share it" means that unused PAL or PAL frequencies not assigned may be used as GAA. If not used by PAL and not required to be protected, the spectrum in the entire CBRS band is open to GAA.

Licensed by Rule: No formal license is required, but GAA users must follow all FCC rules.

Open to Anyone: All users of any size or network type may use GAA spectrum and request a grant. Grants are in 10 MHz increments. Not FIFO. All who wish to use may use.

Play Nice in the Sandbox/Cooperate: Part 96 requires users of GAA spectrum to "cooperate". This means intentional interference is frowned upon. Make sure to cooperate in the band.

How Much Spectrum? How Available is the Spectrum? As much as 150 MHz…and yes, you may request it all. Not First In-First Out. May be crowded in dense areas. May require individual coordination or work with the SAS.

Using Priority Access Licenses (PAL) – the Upcoming Auction

Per Part 96 Spectrum Available for PALs: Each PAL shall be authorized to use a 10-megahertz channel in the 3550-3650 MHz band. PAL Auction s are likely to begin June 25, 2020 per recent FCC Public Notice.

When Not in Use: PALs are "use or share" – meaning when not actually being used, PAL spectrum even purchased at auction may be used opportunistically by GAA users requesting the spectrum through a SAS.

Auction Rules: Not yet formally set by the FCC. Rules PN in early 2020 with auction on June 25, 2020. Other FCC auctions before PAL.

Size and Availability: 10 MHz channels. Apportioned by county in all 50 states. Have protection from harmful interference by GAA users. May purchase up to 40 MHz by county. Performance and buildout requirements. Auction's will likely have bidding credits and may have aggregate bidding. All PALs may be sold (without reserve).

Why PAL: Provides much greater protection and access. Dedicated networks should consider PAL as reservation of rights when in use can provide "like licensed" access. SAS assigns the frequency. In other words, the auction is within the PAL spectrum, but purchaser cannot buy a specific frequency. Upside: Protection. Downside: Possible high cost.

Secondary Market: The FCC has maintained that portions of a PAL may be leased or otherwise disaggregated. It is likely this will create a vibrant secondary market. Unlike pure licenses, spectrum may not be shelved, but it can be leased opening up many new possibilities for access to PAL.

CPE-CBSD Installation – Over the Air

CPE-CBSD Over the Air Registration and Grant Request – When Other Means Not Available (e.g. CPI using cell phone, fiber or Ethernet connection, or other valid back channel)

- ***When to Use This: If you are operating a high power CBSD (Category A – Over +23 dBm/10 MHz to +30 dBm/10 MHz or Category B - +30 dBm/10 MHz - +47 dBm/10 MHz) and it is unable to be physically connected to the Internet or have a backchannel available (other than over-the-air) then you need a mechanism to register the CBSD with the SAS and ask for and get a frequency grant.***

You can do this according to the FCC's Knowledge Data Base entry:
https://apps.fcc.gov/oetcf/kdb/forms/FTSSearchResultPage.cfm?id=229297&switch=P

Notable: Must have no alternative. Must be regulated at to amount and power of transmission. Must use the AP/eNodeB/Base Station already granted (approved) spectrum. Must pass lab testing according to the requirements of the KDB.

Living with Each Other in the CBRS Band – Co-Existence

§96.35 General authorized access use. (Per Part 96)

(a) General Authorized Access Users shall be permitted to use frequencies assigned to PALs when such frequencies are not in use, as determined by the SAS, consistent with §96.25(c).

(b) Frequencies that are available for General Authorized Access Use shall be made available on a shared basis.

(c) General Authorized Access Users shall have no expectation of interference protection from other General Authorized Access Users operating in accordance with this part.

(d) General Authorized Access Users must not cause harmful interference to and must accept interference from Priority Access Licensees and Incumbent Users in accordance with this part.

(e) General Authorized Access Users operating Category B CBSDs must make every effort to cooperate in the selection and use of available frequencies provided by an SAS to minimize the potential for interference and make the most effective use of the authorized facilities. Such users shall coordinate with an SAS before seeking station authorization, and make every effort to ensure that their CBSDs operate at a location, and with technical parameters, that will minimize the potential to cause and receive interference among CBSDs. Operators of CBSDs suffering from or causing harmful interference are expected to cooperate and resolve interference problems through technological solutions or by other mutually satisfactory arrangements.

47 CFR Part 96, the WInnForum Specifications, References

FCC Title 47 CFR Part 96 Rules: Governing FCC Rules for the 3.5 GHz band, commonly known as CBRS. See the Part 96 rules at the Electronic Code of Federal Regulations: **https://www.ecfr.gov/cgi-bin/text-idx?SID=c7f0d04cb455d4e41f359a251b4b0435&mc=true&node=pt47.5.96&rgn=div5**

Clarifications and OET Laboratory Knowledge Databases (KDB): These entries at the Office of Engineering and Technology of the FCC provide access to clarifications about the rules, testing and use of CBRS by the FCC. Often in the form of Q&A. **https://apps.fcc.gov/oetcf/kdb/index.cfm**

Wireless Innovation Forum (**WInnForum**) Standards and Specifications (Includes: Requirements, Protocols, Best Practices and Operations. See: http://www.winnforum.org and CBRS Baseline Standards (Release 1) and Expanded Features and Functions (Release 2): **https://cbrs.wirelessinnovation.org/cbrs-baseline-specifications**

Private Industry Consortia: **CBRS Alliance** is a provider of LTE and NR based best practices and private standards supporting the commercialization and support for CBRS. They have created the "OnGo" product which provides for central standards, co-existence, and other grouping benefits of their members. Other group consortia may form. **http://www.cbrsalliance.org**

When Can I start in CBRS? Why Use CBRS?

Clean New Band: Available to all CBRS affords a new band (though with incumbents) NOW.

Coverage and Capacity: Adding CBRS will allow new coverage and capacity to networks. Some will use it as primary spectrum others as secondary spectrum.

150 MHz of Mid-Band Spectrum Available: Whether PAL or GAA, a substantial offering of mid-band spectrum for commercial use. Mid-band provides strong propagation potential, decent throughput and speed.

Wi-Fi and CBRS are Not Mutually Exclusive: Most expect that users of CBRS will also use Wi-Fi. They can be complementary.

SAS Coordinated: Spectrum Access System (SAS) provides a center to coordinate use and avoid (to a degree) unwanted or harmful interference.

Private and/or Neutral Host Possibilities: Networks can grow in different ways with CBRS. It can be used in the enterprise indoors, or via wide-areas. Multiple providers can operate in locations by neutral host options. And, private networks can be devised in the platform.

Other Possible Shared Spectrum Bands

- **TV White Space (https://www.fcc.gov/general/white-space) – Mostly in the 698 to 806 MHz band.**
- **2.5 GHz band (Recent FCC Order: https://docs.fcc.gov/public/attachments/DOC-358065A1.pdf)**
- **3100-3550 MHz (Band immediately below CBRS)**
- **3700-4200 MHz – (Band immediately above CBRS) C-Band (Incumbents are Satellite companies with FSS Earth Stations – Receivers for Broadcast) – considered for sharing.**
- **Expanded 5 GHz band**
- **6 GHz band (Being considered for PtMP, Flexible and Shared Use, Wi-Fi (802.11ax), and Other) – Incumbents are mostly PTP backhaul (high power – extended range).**
- **mmWave – Higher frequency bands which have high throughput but less range.**

Many in-between bands being studied by the FCC, NTIA, United States Congress and Industry for shared, flexible, and expanded uses.

Conclusion

CBRS is now available with GAA. It is new and exciting and creates new opportunities and new access. It is not licensed spectrum. It is not license free spectrum. It is shared multi-tier spectrum. It is not "free" spectrum because there are costs. But there are new possibilities and very real access. The experiment is becoming reality now.

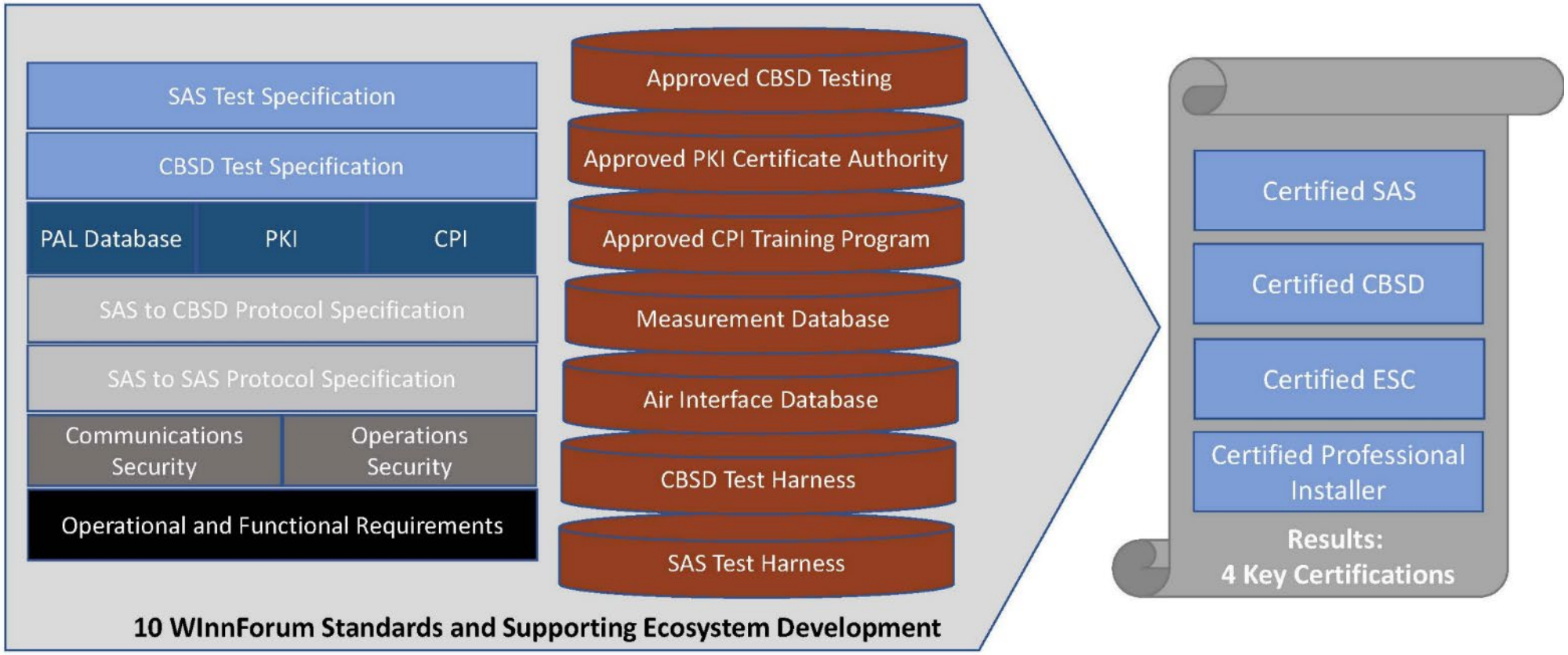
Expect some hiccups to begin with as with anything new, but the possibilities and future expansion are open to the imagination.

CBRS Standards

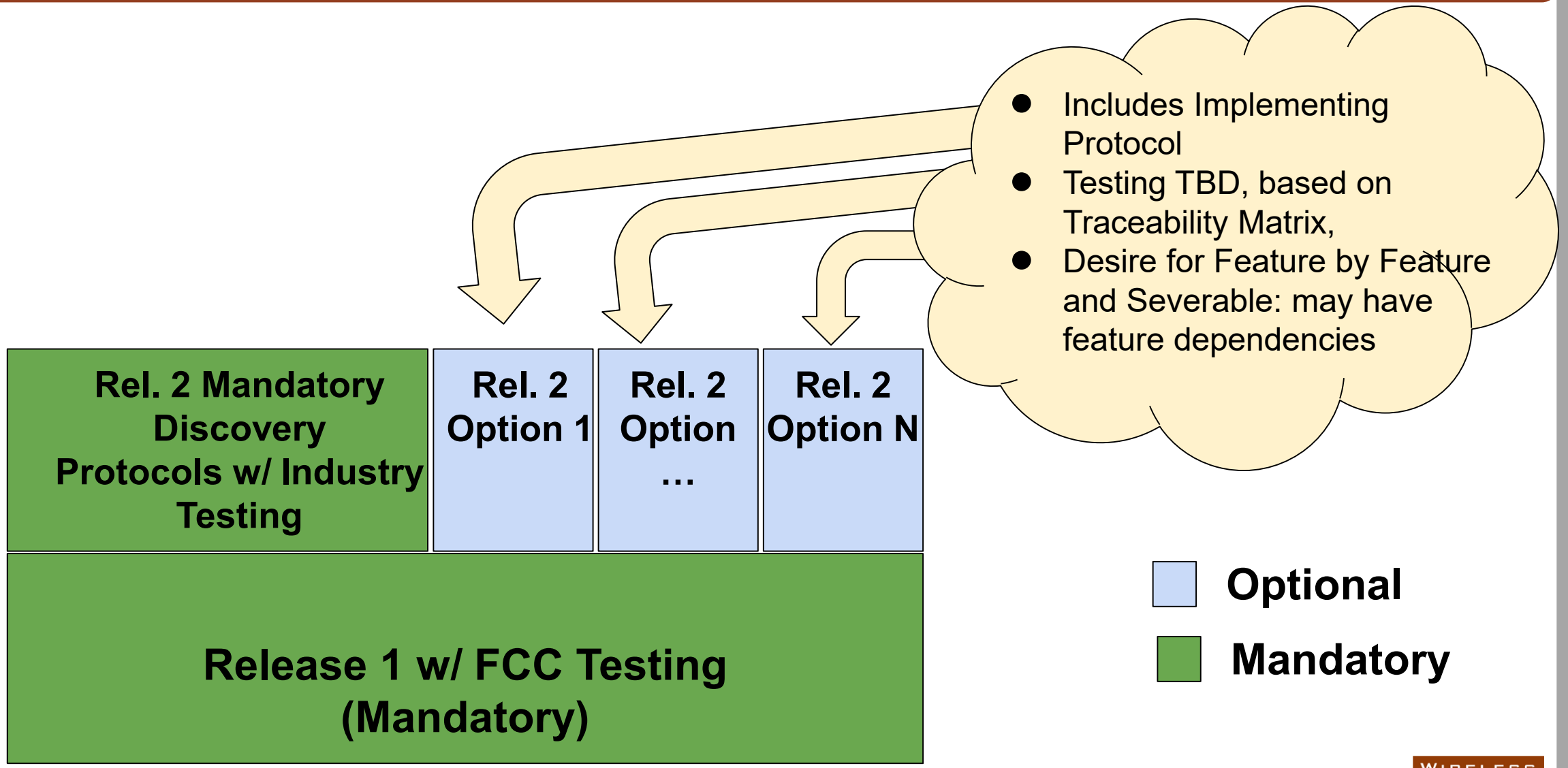
Review of Baselines Standards (Release 1)

Roadmap for Enhancements (Release 2)

Commercializing CBRS: Release 1 Standards and Ecosystem Support



Model for Enhancements to the Baselined Standards (Release 2)



Current Plan for Release 2 Features and Status (Details in follow on slides)

Feature	Requirements (WG1)	Protocols (WG3)	Operations (WG5)	Test (WG4)
Capability Exchange	Complete	In Development	Not Applicable	In Development
ENHANCED_GROUP_HANDLING	Complete	In Development	Not Applicable	Introduced, Not Started
PAL Secondary Market Support	Release 1	To Be Determined	In Development	To Be Determined
PAL Operations (i.e., Channel Mapping)	Release 1	To Be Determined	In Development	To Be Determined
Support for 1D and 2D Antenna Patterns	Complete	In Development	In Development	Introduced, Not Started
Indoor Penetration Loss	In Development	Introduced, Not Started	To Be Determined	Introduced, Not Started
Enhanced CPE-CBSD Support	In Development	In Development	In Development	Introduced, Not Started
Enhanced Propagation Models	Introduced, Not Started	Not Applicable	Not Applicable	Introduced, Not Started
Flexible Grant Request	Not Applicable	In Development	Not Applicable	Introduced, Not Started
GAA Coexistence Support	In Development	In Development	In Development	Introduced, Not Started
Grant Update	To Be Determined	In Development	Not Applicable	Introduced, Not Started
New Response Codes	Not Applicable	In Development	Not Applicable	Introduced, Not Started
Registration Enhancements	In Development	Introduced, Not Started	To Be Determined	Introduced, Not Started
Support for beamforming	To Be Determined	To Be Determined	To Be Determined	To Be Determined

Reminder: Release 2 will be active when the Capability Exchange feature has been completed. Release 2 will continually evolve as new features are added. An individual feature will be considered complete and available for adoption when the associated test has been balloted and approved.

Key
Not Applicable
Introduced, Not Started
In Development
Complete

Self Testing is Being Considered for Features Not Impacting Part 96

- **Companies must agree to Policies and Procedures for Self Testing balloted and approved by the WInnForum members to claim "conformance" with WInnForum Standards for that feature, including:**
  - Agreeing to follow the test specifications defined by the WInnForum CBRS Test and Certification work group for the mandatory Release 2 procedures and for supported Release 2 optional features
  - Agreeing to use the WInnForum test harness developed by the WInnForum CBRS Test and Certification work group for supported features
  - Agree to submit, on company letter head, a signed letter to the WInnForum summarizing the testing for each feature, including the output of the test harness, if applicable, and indicating that all tests were passed
- **WInnForum will maintain a public website detailing which products are compliant with which feature**
- **Will start with Feature-by-Feature case, but may later move to feature bundle profiles**
- **interoperability testing in addition to the self Testing**
  - Not required as part of certification
  - Entities might require that as part of their business agreement

Questions? Comments? Your Use?

Let us know your burning CBRS questions!